the nature of the processes resulting in production of the guidelines. IEEE Standards Coordinating Committee 28, Non-Ionizing Radiation Hazards, (SCC 28), the sponsoring committee responsible for development of the standard, is a continuing body meeting regularly at six-month intervals. Subcommittee IV of SCC 28, the subcommittee charged with preparation of the guidelines for the frequency range of 3 kHz to 300 GHz, not only meets also at six month intervals but maintains an ongoing process involving Working Groups whose operations continue during periods between formal meetings of Subcommittee IV. Under ANSI/IEEE rules, every standard must be reviewed at intervals of no less than five years and revised or confirmed, as appropriate. On the other hand, the NCRP established a committee specifically to prepare NCRP Report No. 86.

Once the report was prepared, the committee was disbanded. To update its criteria, the NCRP must now constitute a new committee, not necessarily with any continuity with the former committee. After the three to five-year period required to prepare a report and achieve its approval by NCRP, the committee will again cease to function.

Studies of biological effects of radio-frequency electromagnetic fields progress in dozens of laboratories throughout the world and in epidemiological programs.

Hundreds of papers, providing the results of those studies appear annually in a variety of publications. The ANSI/IEEE process is designed to keep up with developments, not function on an intermittent, infrequent, unscheduled basis. Because of the continuity and protocol of SCC 28 Subcommittee IV, the Commission, in its forthcoming Report and Order, could specify compliance with the current ANSI/IEEE version of C95.1 and be assured that, even in the absence of *Notices of Proposed Rule Making* ("NPRM") the standard would be up-dated as a matter of course. For example, spectrum user could be alerted to the revision by a simple notice.

The ANSI standard is also preferable to NCRP because it is four years more recent and based upon more comprehensive and up-dated scientific research and literature.

II. ANSI/IEEE is Representative of a Broader Community than NCRP

At the time of preparation of the 1992 standard, Subcommittee IV included approximately 120 members and was co-chaired by O.P. Gandhi, a Professor at the University of Utah, and Dr. E.R. Adair from the John B. Pierce Laboratory and Yale University. The membership was predominantly from academia and from both industrial and governmental laboratories. Disciplines represented included biology, physiology, behavioral psychology, medicine, epidemiology, statistics, and engineering. "Fourteen subgroups constituted the Biological Validation Working Group, comprising scientists and experts in the following disciplines: (1) Behavior, (2) Biorhythms, (3) Cardiovasculature, (4) Central Nervous System, (5) Development and Teratology, (6) Endocrinology, (7) Visual Systems, (8) Genetics, (9) Modulation (RF), (10) Hematology-Immunology, (11) Metabolism-Thermoregulation, (12) Oncology, (13) Combined Effects, and (14) Physiology."[3]

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[3] ANSI/IEEE C95.1-1992, page 27.

The parent committee (SCC 28) that approved the Subcommittee IV submission was chaired by T.F. Budinger, a medical doctor, and included approximately 50 members from a variety of disciplines.

In contrast, the committee that prepared NCRP Report No. 86 included a chairman and five members. In addition, the committee had five advisory members and five consultants participating in its work. The chairman and three other members of the committee were members also of Subcommittee IV of IEEE SCC 28. Within the group of ten NCRP advisory committee members, five were also members of Subcommittee IV. Thus, of the sixteen people credited with participation in preparation of NCRP Report No. 86, nine were involved also in the work of Subcommittee IV which produced ANSI/IEEE C95.1-1992.

In addition to the factor of currency, the broader participation in the development of the ANSI/IEEE standard as compared with the NCRP standard is a strong inducement for favoring ANSI/IEEE over NCRP. The ANSI/IEEE standard was approved by an overwhelming majority of Subcommittee IV and SCC 28. In accordance with ANSI and IEEE rules, all dissents required a response. In the few instances in which there were dissents, the majority of dissents were resolved by approval of modifications to the draft. With respect to the remaining dissents, the subcommittee provided the reasons for retaining the wording of the draft.

III. Similarities and Differences are Found Between ANSI/IEEE and NCRP Standards

A. Frequency Range

The first, and perhaps most obvious difference between the ANSI/IEEE and NCRP standards is with respect to the range of frequencies covered. NCRP covers the range only from 0.3 MHz (300 kHz) to 100 GHz. On the other hand, ANSI/IEEE covers the range from 3 kHz (0.003 MHz) to 300 GHz. The very low frequencies between 3 and 300 kHz are employed for certain specialized applications of communications over great distances. The frequency range from 100 to 300 GHz is becoming increasingly important with the expanded employment of the spectrum for data transmission and as the technology of generation and detection at the higher frequencies advances.

B. Controlled/Uncontrolled versus Occupational/General-Population Environments

The ANSI standard offers a two-tiered exposure criterion that is clearly superior to NCRP. The use of "controlled" and "uncontrolled" exposure environments by ANSI accounts for a given individual and her/his environment. In contrast, the NCRP exposure criterion of "occupational" and "general-population" environments accounts only for the individual.

ANSI/IEEE employs the terms "controlled" and "uncontrolled" to define the circumstances for applying one tier or the other. "Controlled environment" is defined as follows: "Controlled environments are locations where there is exposure that may be incurred by persons who are aware of the potential for exposure as a concomitant of employment, by other cognizant persons, or as the incidental result of transient passage through areas where analysis shows the exposure levels may be above those shown [in the criteria for uncontrolled environments but less than the criteria for controlled environments]." "Uncontrolled environment" is defined by ANSI/IEEE as follows: "Uncontrolled environments are locations where there is the exposure of individuals who have no knowledge or control of their exposure. The exposures may occur in living quarters or workplaces where there are no expectations that the exposure levels may exceed [the criteria specified for the uncontrolled environment]."

ANSI/IEEE in its use of "controlled" and "uncontrolled" logically notes that the more stringent criteria for the uncontrolled environment need not be applied where exposure is momentary as in "transient passage." On the other hand, ANSI/IEEE applies the more stringent exposure requirements in the workplace "where there is exposure of individuals who have no knowledge or control of their exposure." NCRP would apply its more stringent exposure limits to, for instance, a visitor to the observation deck on the South Tower of the New York World Trade Center. ANSI/IEEE would apply its less stringent criteria in such a circumstance because the visitor would be exposed for only a brief period of time and very likely only once in an entire lifetime. As a result, ANSI provides an exposure criterion scheme which protects a person based on what they actually do, not who they are.

The "Rationale" section of ANSI/IEEE C95.1-1992 further expands on the two environments as follows:

> "As defined earlier, uncontrolled environments include the domicile and most places where the infirm, the aged, and children are likely to be. It also includes the work environment where employees are not specifically involved in the operation or use of equipment that does or may radiate significant electromagnetic energy and where there are no expectations that the exposure level may exceed those shown in Table 2 [uncontrolled environment criteria]. On the other hand, controlled environments may involve exposure of the general public as well as occupational personnel, e.g., in passing through areas such as an observation platform near a transmitting tower where analyses show the exposure may be above that shown in Table 2 but is below that in Table 1 [controlled environment criteria]. Other exposure conditions include that of the radio amateur who voluntarily and knowledgeably operates in a controlled RF environment."

The more logical division of the tiers by ANSI/IEEE, recognizing that a brief exposure does not warrant stringent exposure standards and that all persons in the workplace should not be subject to the higher allowed exposure tier, deserves a preference over the NCRP workplace/general-population division.

C. Exposure Standards

Both ANSI/IEEE and NCRP base their principal exposure criteria on limiting specific absorption rate (SAR)[4] to 0.4 watt per kilogram for the higher tier and 0.08 watt per kilogram for the lower tier. SAR was selected as the critical exposure parameter because of the results of animal experiments which showed that, although the size of the animal could change dramatically from a small mouse to a large primate, observed effects were consistent

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[4] Defined by ANSI/IEEE as "[t]he time derivative of the incremental energy (*dW*) absorbed by (dissipated in) an incremental mass (*dm*) contained in a volume element (*dV*) of a given density (ρ)." (equation omitted)

in terms of SAR. Since SAR is a parameter not readily measured, the standards are based on external fields calculated to maintain SAR within the boundaries desired.

In the important VHF portion of the RF spectrum running from 30 to 300 MHz, the exposure limits set by ANSI/IEEE and NCRP are constant and identical for both classes of the environment. Again, at frequencies from 300 to 1500 MHz, the permissible exposure limits for the two standards rise at the same rate. Above 1500 MHz, the standards depart from each other. Whereas NCRP limits exposure above 1500 MHz to 5 mW/cm^2 (occupational) and 1 mW/cm^2 (general-population), ANSI/IEEE permits exposure to continue to rise to 10 mW/cm^2 at 3,000 MHz for the controlled environment and to the same level at 15,000 MHz for the uncontrolled environment.

At the upper frequency limit of 300 GHz for the ANSI/IEEE standard, the RF standard meets the ANSI standard for lasers. The laser standard specifies 10 mW/cm^2 at 300 GHz.

In the upper regions of the spectrum, biological effects are confined to the body surface because of the inability of energy to penetrate the body at those higher frequencies. To limit the possibility of biological effects, ANSI/IEEE reduces the averaging time as a function of frequency for the exposure. Whereas NCRP retains a 6-minute averaging time for occupational exposures and 30-minute averaging time for general-population exposures all the way to 100 GHz, ANSI/IEEE limits the averaging time at 100 GHz to only 37 seconds at 100 GHz and 10 seconds at 300 GHz. Consequently, despite the lower power density cap by NCRP, ANSI/IEEE permits less energy absorption over most of the upper frequency region.

At frequencies below 30 MHz both ANSI/IEEE and NCRP recognize that the criterion of limiting SAR becomes less important, and particularly below 3 MHz. At these low frequencies, electric field standards based solely on SAR would carry the potential for shock and burn. Both standards therefore place a cap on the permissible electric field exposure.

NCRP, without any stated logic, also caps the magnetic field exposure to the same power density (100 mW/cm^2) as for the electric field. But the magnetic field does not carry with it the shock and burn potential of the electric field; therefore, ANSI/IEEE permits the magnetic field to continue to rise at the lower frequencies[5] with no adverse consequences insofar as protecting the human population is concerned.

D. Induced and Contact Currents

Unlike NCRP and other standards previously formulated, ANSI/IEEE C95.1-1992 introduces limitations for induced and contact currents. This was done in recognition of the fact that, under some circumstances, compliance with the exposure standards could permit excessive currents to flow through the body.

At the present time, requiring proof of compliance with the induced and contact current standards may have to be deferred because of the absence of reliable instruments and

[5] This recognition is of particular importance to AM broadcasters. The fields associated with the matching networks in tower feeds are predominantly magnetic.

measurement procedures. Furthermore, Subcommittee IV of SCC 28 is considering a revision of the standard based on a recognition that electric field exposure below particular levels would preclude the possibility of inducing excessive body currents. Adoption of that revision would ease the measurement burden imposed upon emitters of electromagnetic energy.

E. Modulation

NCRP notes that certain effects of RF fields under low-frequency modulation had been observed on both *in-vitro* and *in-vivo* preparations. It goes on to say: "It is not known whether these effects pose a risk to health ..." In the interests of caution, NCRP specifies: "If the carrier frequency is modulated at a depth of 50 percent or greater at frequencies between 3 and 100 Hz, the exposure criteria for the general population shall also apply to the occupational exposures."[6]

ANSI/IEEE contains no modulation limitations. In its "Explanation" section, ANSI/IEEE makes the following statement:

> "Biological effects data that are applicable to humans for all possible combinations of frequency and modulation do not exist. Therefore, this standard has been based on the best available interpretations of the extant literature and is intended to prevent adverse effects on the functioning of the human body."

The limitation imposed by NCRP with respect to modulation has no practical effect.

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[6] NCRP Report No. 86, page 286.

Emitters with sufficient power to be of interest from an exposure standpoint do not maintain modulation at frequencies between 3 and 100 Hz at modulation levels in excess of 50 percent for anything more than very short periods. Most transmitting devices cannot maintain such modulation levels at low frequencies without sustaining damage. Since possible effects on the human body have not been determined, and the modulation condition described by NCRP is not likely to be encountered, the omission of any exposure limitation based on modulation is warranted.

IV. Adoption of ANSI/IEEE Would be Consistent with Actions of Other Federal Agencies and Previous FCC Actions

Adoption of any standard other than ANSI/IEEE C95.1-1992 would lead to a chaotic situation within the Federal Government. The Department of Defense has adopted ANSI/IEEE C95.1-1992 as guidance in the avoidance of excess exposure to RF energy. The Occupational Safety and Health Administration employs ANSI/IEEE C95.1-1992 in its enforcement of workplace safety. The Food and Drug Administration is understood to apply the same guidance in connection with its emission standards.

Perhaps most significantly, the Federal Communications Commission has adopted ANSI/IEEE C95.1-1992 for its newest authorized service. Section 24.52 of the FCC Rules and Regulations specifies the following:

> "**RF hazards**. - (a) Licensees and manufacturers are required to ensure that their facilities and equipment comply with IEEE C95.1-1991 (ANSI/IEEE C95.1-1992), "Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz." ----- The limits for

> both "controlled" and "uncontrolled" environments, as defined by IEEE C95.1-1991, will apply to all PCS base and mobile stations, as appropriate. The application for equipment authorization must contain a statement confirming compliance with IEEE C95.1-1991. Technical information showing the basis for this statement must be submitted to the Commission upon request."

In addition to consistency with Federal actions, IEEE Standards Coordinating Commitee 34 (SCC 34) is starting work on the development of product standards. With respect to RF exposure. SCC 34 will base its standards on IEEE C95.1-1991.

V. "ALARA" - the "Slippery Slope"

Some would advocate application of the principle known as "As Low as Reasonably Achievable" (ALARA). But adoption of the ALARA principle does, indeed, put one on a "slippery slope." Such an approach to protection of the public from possible effects from electromagnetic fields has a surface appeal until thought is given to the consequences. "Reasonable" can have a variety of meanings depending on the individual or governmental entity. To some, "reasonable" may mean the total exclusion of an emitter from the vicinity of a community despite recognition of beneficial aspects of the service. Others may be willing to permit the emission to take place because of the desirability of the service but insist on provisions that will make the service too expensive for the general public.

ALARA is not a viable approach to protection. It can deprive the public of useful services and cause great economic harm.

VI. Conclusions

The commission should adopt ANSI/IEEE, in its entirety, as a "living document" in its revision of RF radiation exposure guidelines. ANSI/IEEE is superior to the NCRP standard for a number of reasons: (1) it is the most recently formulated standard; (2) it has been prepared by a more representative body of science experts; (3) it incorporates an ongoing process of review; (4) it requires a high degree of consensus prior to any modification; (5) in the few frequency ranges of the spectrum in which the exposure guidelines diverge, ANSI is more logical and, for the most part, is more protective than NCRP; (6) it is based upon scientific research and literature widely endorsed by experts across multiple disciplines, and (7) it is consistent with prior FCC actions and with the actions of other Federal agencies. Where differences occur between the two standards, ANSI/IEEE has provided the scientific basis for such differences and employs a preferable and more consistent logic.

Jules Cohen

Jules Cohen, P.E.

February 9, 1996

APPENDIX B

PROTECTION OF DOD PERSONNEL FROM EXPOSURE TO RADIO FREQUENCY RADIATION AND MILITARY EXEMPT LASERS

DEPARTMENT OF DEFENSE

Department of Defense
INSTRUCTION

February 21, 1995
NUMBER 6055.11

USD(A&T)

SUBJECT: Protection of DoD Personnel from Exposure to Radiofrequency Radiation and Military Exempt Lasers

References: (a) DoD Instruction 6055.11, "Protection of DoD Personnel from Exposure to Radiofrequency Radiation," August 20, 1986 (hereby canceled)
(b) DoD Instruction 6050.6, "Exemption for Military Laser Products," May 1, 1978 (hereby canceled)
(c) DoD Directive 1000.3, "Safety and Occupational Health Policy for the Department of Defense," March 29, 1979
(d) Institute of Electrical and Electronics Engineers (IEEE) C95.1-1991, "IEEE Standard for Safety Levels with Respect to Human Exposure to Radiofrequency Electromagnetic Fields, 3 kHz to 300 GHz," April 27, 1992
(e) through (k), see enclosure 1

A. REISSUANCE AND PURPOSE

This Instruction:

1. Reissues reference (a), incorporates and cancels reference (b), supplements reference (c), adopts the RF exposure guidelines in reference (d), and updates procedures for protection of personnel from radiofrequency electromagnetic fields (RF EMF).

2. Establishes policy and assigns responsibilities, pursuant to reference (c), for individual military laser products that are exempt from the radiation safety performance standards set forth in reference (e). The exemption is set forth in enclosure 2 and amended by enclosure 3.

B. APPLICABILITY AND SCOPE

This Instruction:

1. Applies to the Office of the Secretary of Defense (OSD), the Military Departments, the Chairman of the Joint Chiefs of Staff, the Unified Combatant Commands, the Uniformed Services University of the Health Sciences, the Defense Agencies, and the DoD Field Activities (hereafter referred to collectively as "the DoD Components").

2. Applies to all DoD civilian and military personnel who may be exposed to RF EMF, except for patients undergoing diagnostic or therapeutic procedures in medical and dental treatment facilities.

3. Applies to operations during peacetime, and to the maximum extent possible during wartime, to limit personnel exposure to RF EMF. It is recognized that during war or combat operations, requirements in this Instruction may not be feasible.

4. Applies to laser products that are used exclusively by DoD Components and are (a) designed for actual combat or combat training operation; or are (b) classified in the interest of national security. Its provisions do not apply to laser products intended primarily for indoor classroom training and demonstration, industrial operations, scientific investigation, or medical application.

C. DEFINITIONS

Terms used in this Instruction are defined in enclosure 4.

D. POLICY

It is DoD policy to:

1. Identify, attenuate, or control by engineering design, protective equipment, administrative actions, or a combination thereof, hazardous RF EMF and other dangers associated with DoD electronic equipment. That policy shall be emphasized during all phases of equipment design, acquisition, installation, operation, and maintenance.

2. Limit personnel RF exposure to levels that are within the permissible exposure limit (PEL) in enclosure 5.

3. Define and control areas in which RF exposure to personnel could exceed the PEL, including simultaneous exposure from more than one RF emitter.

4. Ensure personnel are aware of potential RF exposures in their workplaces and duty assignments, and the control measures imposed to limit their RF exposures.

5. Investigate and document RF overexposure incidents.

6. Comply with as many of the laser safety standards set forth in reference (e) as practicable.

E. RESPONSIBILITIES

1. The Deputy Under Secretary of Defense for Environmental Security as the DoD "Designated Agency Safety and Health Official," shall:

a. Provide policy and guidance on RF and laser protection matters in the Department of Defense.

b. Serve as the principal point of contact with Federal Agencies on RF and laser protection matters.

c. Establish, as an integral element of the Defense Environmental Security Council (DESC) and related Board and Committee structure, the Tri-Service Electromagnetic Radiation Panel (TERP), which serves as a resource of resident expertise in coordinating and addressing RF exposure and biological research issues, and the Laser System Safety Working Group (LSSWG) as a resource of expertise in laser issues.

2. The Heads of the DoD Components shall establish and maintain RF EMF and laser protection programs under the cognizance of the DoD Components' designated "Safety and Occupational Health Officials" to carry out this Instruction. Such programs shall include the minimum requirements in enclosure 5.

F. PROCEDURES

The RF and laser protection program of the DoD Components shall include the elements described in enclosures 5 and 6.

G. EFFECTIVE DATE

1. This Instruction is effective immediately. Detailed implementing instructions are only necessary to provide for any DoD Component-unique situations.

2. DoD Components must satisfy their bargaining obligations with unions under U.S.C. Chapter 71 prior to implementing any changes generated by this Instruction. The Instruction does not supersede any existing collective bargaining agreement until the agreement expires and the bargaining obligation is fulfilled.

Paul G. Kaminski

Paul G. Kaminski

Enclosures - 8
1. References

2. Letter of Exemption
3. Letter Amending Exemption
4. Definitions
5. DoD RF and Laser Program Elements
6. Application and Measurements
7. RF Hazard Warning Signs
8. Sample Laser Exemption Notification

DEFINITIONS

1. Averaging Time (T_{avg}). The time period over which exposure is averaged for determining compliance with a PEL value.

2. Controlled Environment. Locations where RF exposures may exceed the levels given in table 6-2-1, but do not exceed the levels in table 6-1-1 (enclosure 6, attachment 6-1). Generally, controlled environments represent areas that may be occupied by personnel who accept potential exposure as a concomitant of employment or duties, by individuals who knowingly enter areas where such levels are to be expected, and by personnel passing through such areas. Existing physical arrangements or areas, such as fences, perimeters, or weather deck(s) of a ship may be used in establishing controlled environments.

3. Electric Field Strength (E). The magnitude of the electric field component of an electromagnetic wave expressed in units of volts per meter (V/m).

4. Exposure, Partial Body. Partial-body exposure results when RF EMF are substantially nonuniform over the body. Fields that are nonuniform over volumes comparable to the human body occur due to highly directional sources, re-radiating sources, standing waves, or in the antenna's near-field region.

5. Far-Field Region. The region far enough from an antenna that the radiated power per unit area decreases with the square of the range. In the far-field region, the field has a predominantly plane-wave character; i.e., uniform distributions of electric and magnetic fields in planes transverse to the direction of propagation.

6. Fluence. The energy density of the EMF when integrated over the duration of the exposure, usually expressed in units of joules per square centimeter (J/cm^2).

7. Hertz (Hz). The unit for expressing frequency. One hertz equals one cycle per second. Commonly used multiples are kilohertz (kHz), megahertz (MHz), and gigahertz (GHz).

8. Human Resonance Range. The frequency region where absorption of RF energy in the body as a whole is enhanced. For sizes ranging from a baby to an adult, peak absorption varies depending on the individual's size relative to the wavelength and orientation relative to the polarization of the field. The PELs have been established to cover the range of human sizes, shapes, and positions.

9. Magnetic Field Strength (H). The magnitude of the magnetic field component of an electromagnetic wave expressed in units of amps per meter (A/m).

10. <u>Mathematical Expressions</u>. Standard notations are used in the text and the tables to show operations, such as, a/b to mean b divides a, ab or $a(b)$ or $(a)(b)$ to mean a multiplies b, a^b to mean a raised to the bth power, and the symbol $<$ to mean less than.

11. <u>Near-Field Region</u>. A region generally in close proximity to an antenna or other radiating structure in which the electric and magnetic fields do not exhibit a plane-wave relationship, and the power does not decrease with the square of distance from the source but varies considerably from point to point. The near-field region is further subdivided into the reactive near field, which is closest to the radiating structure and contains most or nearly all of the stored energy, and the radiating near field, where the radiating field predominates over the reactive field but lacks substantial plane-wave character and is complicated in structure. (For most antennas, the outer boundary of the reactive near-field region is considered to occur at a distance of one-half wavelength from the antenna surface.)

12. <u>Permissible Exposure Limit (PEL)</u>. The PEL is established for the protection of personnel. There are no expectations that any adverse health effects will occur with exposures that are within the PEL, even under repeated or long-term exposure conditions. In controlled environments, where restrictions on access may be implied, the PEL is based on maintaining exposures below a SAR of 0.4 W/kg. That level incorporates a safety factor of 10 below a SAR of 4 W/kg that is considered as a threshold, above which, there is an increasing possibility for adverse biological effects, but at or below which, there is no established evidence of any harm to health. In uncontrolled environments, where access is not restricted, lower levels (equivalent to a SAR of 0.08 W/kg) have been adopted over the human resonance range as a consensus for maintaining lower exposure levels in public areas. Since SAR is not an easily measured quantity, PELs are given in terms of measurable field parameters E, H, or S as a means for demonstrating compliance with SAR.

13. <u>Plane Wave</u>. An EM wave characterized by mutually orthogonal electric and magnetic fields that are related by the impedance of free space (377 ohms). For plane waves, S, E, and H exhibit the following relationship: $S = E^2/3770 = 37.7\ H^2$, where S is in units of mW/cm^2, E is in V/m, and H is in A/m.

14. <u>Power Density (S)</u>. Radiated power per unit area, expressed in units of watts per square meter (W/m^2) or milliwatts or microwatts per square centimeter (mW/cm^2 or $\mu W/cm^2$). The term, plane-wave-equivalent power density, refers to the magnitude of S that would exist for an EM wave in free space having the same E or H fields.

15. <u>Radio Frequency (RF)</u>. The RF region is defined as extending from 3 kHz to 300 GHz.

16. Re-Radiated Field. EMF resulting from currents induced in a secondary, predominantly conducting object by EM waves incident on that object from one or more primary radiating structures or antennas. Re-radiated fields are sometimes called reflected or scattered fields. The scattering object is sometimes called a re-radiator, or a secondary or parasitic radiator.

17. RF "Hot Spot." A highly localized area of relatively intense RF EMF that manifests itself as:

a. Intense electric or magnetic fields immediately adjacent to conductive objects immersed in lower intensity ambient fields, or

b. Localized areas where there exist a concentration of RF fields caused by reflections or narrow beams produced by high-gain radiating antennas or other highly directional sources.

c. For both descriptions, the fields are characterized by very rapid changes in field strength. RF hot spots are normally associated with very nonuniform exposure of the body (partial-body exposure). The term RF hot spots should not be confused with an actual thermal hot spot in an absorbing body.

18. Root-Mean-Square (rms). The effective value, or the heating value, of a periodic EM wave. The rms value for E or H fields is obtained by taking the square root of the mean of the squared values for E or H over an area equivalent to the vertical cross-section of the human body (projected area).

19. Specific Absorption Rate (SAR). The time rate at which RF energy is imparted to an element of biological body mass. Average SAR in a body is the time rate of the total energy absorbed divided by the total mass of the body. SAR is expressed in units of watts per kilogram (W/kg). Specific absorption (SA) refers to the amount of energy absorbed over an exposure time period and is expressed in units of joules per kilogram (J/kg).

20. Uncontrolled Environments. Locations where RF exposures do not exceed the PELs in table 6-2-1 (enclosure 6, attachment 6-2). Such locations generally represent living quarters, workplaces, or public access areas where personnel would not expect to encounter higher levels of RF energy.

DOD RF AND LASER PROGRAM ELEMENTS

1. RF PEL. No practice shall be adopted or operation conducted involving planned exposure of personnel to RF levels in excess of the applicable PEL.

a. RF PELs are derived from the recommended exposure levels in American National Standards Institute (ANSI)/IEEE C95.1-1992, which is published as IEEE C95.1-1991 (reference (d)), and serves as a consensus standard developed by representatives of industry, scientific communities, Government Agencies, and the public.

b. The basic dosimetric parameter for RF exposure is a whole-body specific absorption rate (SAR) of 0.4 watts per kilogram (W/kg). That level incorporates a safety factor of 10 below a SAR of 4.0 W/kg, which has been determined to be a threshold for occurrence of potentially deleterious biological effects in people. PELs are given in terms of measurable field parameters as a convenient correlation to the SAR.

c. For human exposure to RF EMF from 3 kHz to 300 GHz, the PELs, in terms of root-means-square (rms) electric (E) and magnetic (H) field strengths, plane-wave equivalent power densities (S), and induced body currents that can be associated with exposures to such fields, are given in tables 6-1-1 and 6-2-1 (enclosure 6, attachments 6-1 and 6-2) for both controlled and uncontrolled environments.

(1) Controlled environments are areas where exposure levels may exceed the values in table 6-2-1, but do not exceed the values in table 6-1-1 (enclosure 6, attachments 6-2 and 6-1). Exposures associated with a controlled environment include the following:

(a) Exposure that may be incurred by personnel who are aware of the potential for RF exposures as a concomitant of employment or duties.

(b) Exposure of individuals who knowingly enter areas where higher levels can reasonably be anticipated to exist.

(c) Exposure that may occur incidental to transient passage through such areas.

(2) Uncontrolled environments are locations where exposure levels are less than the values given in table 6-2-1 (enclosure 6, attachment 6-2). Such environments include living quarters, workplaces, or public areas where there are no expectations that higher RF levels should be encountered.

d. The PELs for controlled environments in table 6-1-1 (enclosure 6, attachment 6-1) are based on scientifically derived values to limit the absorption of electromagnetic energy in the broader human resonance frequency range of 100 kHz to 6 GHz, and to restrict induced currents in the body to limit the localized SAR occurring in the feet, ankles, wrists, and hands of personnel. For uncontrolled environments, further reduction occurs in table 6-2-1 (enclosure 6, attachment 6-2) to control RF levels in areas of domicile and workplaces that are not associated with RF emitters. That reduction is not based on lessening any known adverse health effect, but is a consensus designed to maintain lower exposure levels outside of well-defined areas. The basis and the rationale for the PELs in controlled and uncontrolled environments are addressed in IEEE C95.1-1991 (reference (d)). Refer also to National Council on Radiation Protection (NCRP) Publication No. 119 and American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Values (TLVs) (references (g) and (h)) for additional information on RF EMF.

e. Relaxation of the whole-body averaged PELs given in tables 6-1-1 and 6-2-1 (enclosure 6, attachments 6-1 and 6-2) is allowed for partial-body exposure conditions or through application of the SAR exclusion rule or the low-power device exclusion rule as specified in subsection B.6. of enclosure 6.

f. Additional RF exposure limits or exposure restrictions are not imposed in case of pregnancy.

2. EMF Exposure Guidance for High Power Microwave (HPM) and Electromagnetic Pulse (EMP) Simulators

a. HPM Systems. For exposure in controlled environments involving HPM narrow-band systems, the exposure limit for any single pulse or series of pulses lasting less than 10 seconds is given in table 6-3-1 (enclosure 6, attachment 6-3). For uncontrolled environments, exposure shall conform with the PELs in table 6-2-1 (enclosure 6, attachment 6-2).

b. EMP Simulator Systems. For exposure in controlled environments involving broad-band EMP simulators, the exposure limit is given in table 6-3-1 (enclosure 6, attachment 6-3). For uncontrolled environments, exposure shall conform with the PELs in table 6-2-1 (enclosure 6, attachment 6-2).

3. RF Warning Signs

a. The RF hazard warning sign format in figure 7-1 of enclosure 7 is derived from the RF warning symbol published in ANSI C95.2-1982 (reference (i)). Variations to include subdued signs for camouflage or tactical reasons, or to provide improved visibility under certain lighting conditions, are authorized, provided the general layout of the sign remains the same.

b. RF warning signs are required at all access points in which levels exceed the controlled environment PELs listed in table 6-1-1 (enclosure 6, attachment 6-1). Where the RF levels exceed the uncontrolled environment PELs given in table 6-2-1 (enclosure 6, attachment 6-2), RF warning signs should be posted in areas as determined by safety, engineering or occupational health professionals. Instructional or warning statements should be inserted on the signs. Examples of such statements are shown in figure 4-1 of enclosure 4. In concert with safety and occupational health professionals, commanders may waive the requirement for signs when necessary in response to military operational considerations, provided personnel are informed of possible hazards by other means.

c. In areas where access to levels greater than 10 times the controlled environment PELs may exist, warning signs alone do not provide adequate protection. Other warning devices, such as flashing lights, audible signal barriers, or interlocks, are required depending on the potential risk of exposure.

4. RF Protective Clothing. RF protective clothing is not authorized for routine use as a means of protecting personnel. Protective equipment, such as electrically insulated gloves and shoes for protection against RF shock and burn or for insulation from the ground plane, is authorized where necessary for compliance with the induced current limits of tables 6-1-1 and 6-2-1 (enclosure 6, attachments 6-1 and 6-2).

5. Investigation of RF Incidents

a. Each DoD Component shall investigate and document incidents involving personnel exposure that may exceed the PELs given in table 6-1-1 (enclosure 6, attachment 6-1), after including adjustments to the PEL, such as, spatial and time averaging, partial-body exposure, etc., as discussed in the application and measurement sections in enclosure 6.

b. For personnel exposures occurring at, or above, five times the adjusted PELs in table 6-1-1 (enclosure 6, attachment 6-1), the following additional actions are required:

(1) RF EMF measurements for documentation of the RF exposure that may have been received.

(2) Medical examination and recommendations for medical followup.

(3) Documentation providing a description of the circumstances surrounding the exposure incident, statements from personnel involved in that incident, and recommendations to prevent similar occurrences.

c. The DoD Components shall maintain a repository file for all investigations of exposure incidents in which personnel were exposed to RF levels in excess of five times the table 6-1-1 adjusted PELs (enclosure 6, attachment 6-1).

6. RF Safety Training. DoD personnel who routinely work directly with equipment that emits RF levels in excess of the PELs in table 6-1-1 (enclosure 6, attachment 6-1), or whose work environment contains equipment that routinely emits levels in excess of the PELs in table 6-1-1 (enclosure 6, attachment 6-1), shall receive training so that they are aware of the potential hazards of RF, established procedures and restrictions to control RF exposures, and their responsibility to limit their exposures. Training shall be conducted before assignment to such work areas. Refresher training should be given and may be incorporated into other periodic safety training programs.

7. Measurement and Evaluation of RF Fields. The DoD Components should evaluate RF hazards using the measurement procedures and techniques recommended in IEEE C95.3-1991 (reference (j)), as basic guidance. That requirement does not preclude using other RF measuring and evaluation methodologies.

a. Records of surveys, reports, calculations, and control measures imposed shall be maintained for each fielded RF emitter which is capable of exceeding the PELs in table 6-2-1 (enclosure 6, attachment 6-2).

b. Where multiple RF emitters may be collocated in fixed arrangements, such as aboard ships or at communication sites, RF evaluation data should include a determination of the weighted contribution from expected simultaneously operated emitters to ensure that personnel are not exposed to effective RF levels above the PEL.

8. RF Bioeffects Research. Biomedical effects research of EMF by the DoD Components shall be coordinated with the TERP.

9. Research and Development. The DoD Components involved in research, development, testing, and evaluation (RDT&E), and in acquisition of RF generating equipment, shall identify RF control requirements and incorporate protection measures or identify operational restrictions before fielding. System safety studies pursuant to MIL-STD-882C (reference (k)) shall use the PELs of enclosure 6.

10. Operational RF Systems. The DoD Components shall include RF safety and occupational health requirements in technical orders, handbooks, manuals, and other publications about siting, operation, and maintenance of RF sources and equipment. Installations operating applicable RF emitters shall maintain documentation defining locations categorized as "RF controlled and uncontrolled environments."

where T_{exp} is the exposure duration in that interval expressed in the same time units as T_{avg}.

5. Measurements to determine adherence to the PEL should be made at distances of at least 20 centimeters (cm) or greater from any reradiating objects or reflective surfaces.

6. The PEL values may be relaxed in the case of partial-body exposure, or by reference to the SAR exclusion rules, or the low-power device exclusion rules, as follows:

a. Partial-Body Exposure. In the case of partial-body exposure conditions from highly directional sources or from substantially nonuniform fields over an area equivalent to the body, relaxation of the PELs of section A. of tables 6-1-1 and 6-2-2 (attachments 6-1 and 6-2) is allowed for exposures limited to a portion of the body. Maximum values for partial-body exposures limits are in section D. of tables 6-1-1 and 6-2-1 (attachments 6-1 and 6-2). Partial-body limits do not apply in the case of direct exposure to the eyes.

b. SAR Exclusion Rule. The PELs in section A. of tables 6-1-1 and 6-2-1 (attachments 6-1 and 6-2) may be relaxed by reference to SAR limits through calculations or measurements, as follows:

(1) Controlled Environment Exclusion

(a) At frequencies between 3 kHz and 100 kHz, the PEL can be exceeded, if it can be shown that the peak rms current density as averaged over any 1 cm^2 area of tissue and over 1 second does not exceed 0.035(f) mA/cm^2 where f is in kHz.

(b) At frequencies between 100 kHz and 6 GHz, the PEL may be exceeded if the exposure conditions can be shown to produce SARs below 0.4 W/kg as averaged over the whole body, and spatial peak SAR values not exceeding 8 W/kg as averaged over any one gram of tissue; except for the hands, wrists, feet, and ankles where the spatial peak SAR shall not exceed 20 W/kg as averaged over any 10 grams of tissue, and the induced body currents conform with the values in section B. of table 6-1-1 (attachment 6-1).

(c) At frequencies above 6 GHz, where body absorption is quasi-optical and body resonance considerations do not apply, the PELs may be relaxed using the time-averaged limits for partial-body exposures given in section D. of table 6-1-1 (attachment 6-1).

(2) Uncontrolled Environment Exclusion

(a) At frequencies between 3 kHz and 100 kHz, the PEL can be exceeded, if it can be shown that the peak rms